Implementing Learning Models in Virtual Worlds
From Theory to (Virtual) Reality

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Abstract: The main advantage of Desktop Virtual Reality is that it enables learners to interact with each other both in the physical classroom and in a 3D environment. Even though, no explicit theories or models have been developed to contextualise Virtual Learning, instructional designers have successfully employed the traditional approaches with positive results on learners' motivation and engagement. However, there is very little we know when the question comes to the importance of examining and taxonomising the impact of interactions on motivation and engagement as a synergy of learners' concurrent presence. To evaluate the potential of interactions holistically and not just unilaterally, a series of experiments were conducted in the context of our Hybrid Virtual Learning classes underpinned from the instructional designer's decisions to increase the incentives for interactions. Learners' thoughts and preconceptions about the use of virtual worlds as an educational tool were surveyed, whilst, their actions and interactions (in both environments) were observed during their practical sessions. The take away is that the higher the levels of interactivity are, the higher the chances to attract students' attention and engagement with the process will be.

1 INTRODUCTION

Various terms are used to describe Virtual Reality (VR) products. In this paper, the term 'virtual-world or virtual environment' (VE) is translated into a computer generated, 3-dimensional (3D) multiuser environment, whose representations are designed and shaped by individuals, through the use of avatars, in real time. In this definition, VR environments which presume the use of additional hardware equipment—such as head-mounted, haptic or kinetic devices—are excluded.

Virtual environments have been inherently designed to mirror the real-world settings in a vivid and realistic 3D environment (Loke, 2015). Moreover, as such environments are highly customisable, the development of scenarios that cannot be (effortlessly or efficiently) staged or do not even exist in the 'real' world becomes tangible (Chen, 2009). Researchers agree that VR technology has many capabilities and potential to offer in education (Jarmon et al., 2009) whereas, educators, highlight the value and benefits that 3D VEs offer on learners' motivation and engagement (Pellas and Kazanidis, 2015).

The lack of literature related to learning frameworks focused on VEs led educators to integrate the existing learning theories, as an initial stepping stone (Savin-Baden et al., 2010; Wang and Burton, 2013). Consequently, whilst educators and instructional designers were exploring the applications of this alternative tool, strong debates emerged leading to the development of conceptual and empirical frameworks or taxonomies related to learning *in* VEs (Duncan et al., 2012; Lee et al., 2010). Bossard et al. (2008) examined how effective VEs are for learning or training and investigated how the knowledge and skills that have been constructed in VEs are transferred to the real world's applications. Calleja (2014) explored the elements that affect the levels of immersion that learners reach whereas, Childs (2010), depicted how the sense of presence affects their learning achievements.

The extensive utilisation and positive results of VEs in Distance Learning, led to their (partial) incorporation in the traditional face-to-face education so as to enrich and enhance learners' experience (Omieno et al., 2012). A plethora of definitions related to the Blended Learning model exists. The most predominant definition describes

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Blended Learning as the combination of online and face-to-face instruction and interaction both between learners and educators (Graham, 2013). The outcomes of the aforementioned studies are, indeed, very substantial and useful to educators and instructional designers who aim to develop immersive learning activities for their learners. Nevertheless, when it comes to Hybrid Virtual Learning (HVL), the detailed examination does not fully apply, especially from the view and perspective of immersion. As HVL, we define the context where the traditional classroom and the VE are overlapping. In other words, in HVL, educators and learners are simultaneously co-present, interacting with each other in real-time, in the physical and the virtual environment as well. According to Konstantinidis et al. (2009), in such contexts, learning becomes more student-oriented and co-operative whilst, teaching is more interactive and rewarding.

As reported by Lee et al. (2010), most of the existing literature examines and reports how VR *influences* learning but very few studies have been performed to understand how VR *enhances* learning. An example of this argument is the topic of *interaction* and *engagement*. Fernández-Gallego et al. (2013) stress the importance of interactions on the learning activities whilst, Dillenbourg et al. (2002), underline the lack of understanding on developing interactions for different learning objectives. Nevertheless, the attempts to introduce taxonomies and frameworks that map and evaluate them, especially in *HVL scenarios*, are absent.

Interestingly, even when interactions are under researchers' attention, the focus is almost exclusively on the interactivity of the VE per se and not on the interactions that need—or have—to be developed in order to cover learners' needs and aid the learning process (Camilleri et al., 2013; Chodos et al., 2012; Fardinpour and Reiners, 2014; Grivokostopoulou et al., 2016).

On the antipode, the studies that discuss interactions holistically (i.e. both in the physical classroom and the VE), report findings that have been derived from experiments which included the use of external hardware devices (Klompmaker et al., 2013; Kronqvist et al., 2016). However, such devices are not readily available to (most) institutions due to their prohibitive cost. Thereafter, following the common practice route to integrate the outcomes of studies which have been performed in mixed/augmented reality contexts, in a strictly desktop-based HVL model, is absurd.

Ultimately, disregarding partly or even completely the network of interactions that is being developed between the 'real' and the 'virtual' world—between the 'real' students and the 'avatars'—simultaneously, diminishes or even dismisses the essence of the HVL approach as well as restricts educators and instructional designers from reaching its maximum potential.

This brief overview related to the lack of a common taxonomy for describing and classifying the types of interactions that take place in HVL contexts and their impact on learner engagement is a limitation that needs to be systematically examined and evaluated.

In this paper, we discuss some of the most relevant and applicable, to VEs, learning theories and models contextualised with examples related to the instructional designer's perspective. Consequently, we present our perspective and understanding in regard to the content and activities, that educational VEs should include, with particular emphasis on the importance of interactions. Before reaching our conclusions, we make a brief presentation (summary) of the core findings derived from a four-year longitudinal study to examine this content in a HVL scenario. The paper concludes with suggestions and guidance to educators and instructional designers who are particularly interested in utilising VEs in HVL contexts.

2 LEARNING THEORIES

Most of the experiments that have been conducted in VEs have been underpinned from the existing learning theories (Twining, 2009). To authors' knowledge, there are no learning theories exclusively developed to contextualise Virtual Learning. Furthermore, the majority of the existing studies are empirical and usually report the learning benefits of VEs in different educational fields. This is eventually the under-theorisation of research problem in VEs. Savin-Baden et al. (2010) underline that the pedagogical basis for using VEs is under-theorised whereas, Dalgarno and Lee (2010), opposes to the aforementioned argument and suggest that the design of VEs is more intuitive than theory-based. Indeed, educators who use VEs have more pragmatic or practical oriented targets than theoretical focus (Wang and Burton, 2013). However, understanding and theorising how learners acquire knowledge in VEs will help educators to determine what their students can learn and consequently apply the most relevant mechanism to achieve the best possible results (Loke, 2015). In this section, we discuss the most frequently used learning theories that educators utilise to design educational VEs.

2.1 Behaviorism

The ease of repeated transmitting information and feedback to learners in VEs makes 'operant conditioning' viable. Nonetheless, Nelson and Erlandson (2012) warn instructional designers not to develop complex activities, with large-scale goals, as this deconstructs the essence of the behaviorist idea. Instead, what needs to be developed is a set of small tasks, which will build upon the feedback of interactions, until the learning goals are reached.

2.2 Cognitivism

VEs lift many limitations that exist in the 'real' world and can facilitate the 'deep learning process' through their vivid and interactive content. Nevertheless, instructional designers who consider this theory shall keep in mind that, in order to help learners organise and relate new information to their existing cognitive schemas (especially when the subject is highly interconnected and complex), many different representations of content are required (Bryceson, 2007).

2.3 (Social) Constructivism

VEs allows learners to develop, alter, and enhance their content in relation to their personal learning needs and therefore, construct their cognitive schemes and engage with the phenomena they study. Furthermore, the learning process becomes more student-centered and self-directed, whilst the educator gets the role of the designer, instructor, and supporter. Therefore, the focus should be on developing interactive tasks, with particular emphasis on the social tools of VEs. In doing so, the incentives for student collaboration are increase and enable learners to develop their social presence as part of the knowledge construction process (Anderson and Dron, 2011).

2.4 Connectivism

Connectivism, as developed and introduced by Siemens (2005), is a newly formed learning theory which established after developing understanding on how online learning environments can serve as networks to facilitate learning. Driven by the principle of 'knowledge creation' and 'consumption', learners are becoming part of a wider information network which is generated in accordance to individuals' needs and understandings. Nonetheless, as learners are exposed to a continuous and changing information flow, their ability to collect current and relevant information is a critical factor (Kop and Hill, 2008). The application of this theory in VEs relies much on the available nodes (e.g. content and examples) that instructional designers provide learners (e.g. shareable example-artifacts from experts or past students).

2.5 Summary

All and each one of the aforementioned theories share many properties in common but also differ greatly in points. Educators who want to offer their learners engaging and interactive learning experiences should aim to utilise most of them as they offer unique benefits whilst, eliminating the disadvantages and limitations of the others.

3 LEARNING MODELS

In this section, we present some of the most relevant learning models which have been developed based on the aforementioned theories and incorporated successfully in VEs.

3.1 Collaborative Learning

The terms collaborative and cooperative learning are often used interchangeably though they do not represent the same idea. In cooperative learning, the group members work individually and usually asynchronously towards multiple subtasks which are assembled to produce the final outcome (Hasler, 2011). On the other hand, collaborative learning refers to the synchronous social interaction (e.g. dialogue and discussion) that the group members engage in, when working as a team, to develop mutual understanding towards the solution of a given problem or task (Jeong and Chi, 2007).

VR technology emerged with the concept of (social) interactivity in mind. Utilising these features under the principles of the (Social) Constructivism theories, educators' decision to use VEs to undertake a wide range of educational activities, such as role play, simulation, programming, is fully justifiable. Indeed, most of the studies report positive results, especially when it comes to learner embodiment, engagement and motivation (Pirker, 2013).

3.2 Experiential Learning

A generic agreement can be identified in educators' views when it comes to the application and benefits of this model in VEs (Loureiro and Bettencourt, 2014). Indeed, considering the technical characteristics and features of VR, learners can experience information in a real-world-like setting and learn through experimentation (Chen, 2009). Nevertheless, Loke (2015) argues that this model is, by definition, inadequate in explaining how learners' experience in VEs is transferred or translated as knowledge and skills in the real-world context. However, as the author further mentions, experiential learning theory makes particular emphasises on the importance of reflection to make meaning of concrete experiences. Thereby, Loke's suggestion is to emphasise on the reflection process in the exact same way as if the experience was undertaken in the real world's context.

3.3 Situated Learning

When the idea of Situated Learning proposed, VR was not in authors' list as one of the potential extension or application. Thereafter, applying this model in VEs raises the concern of how the acquired knowledge or skills are transferred from the virtual context to the real world? Indeed, for this approach to be effective, various aspects have to be concurrently considered. Loke (2015) suggests that the context of the virtual world should be realistic or 'authentic' enough so as to enable learners perceive it in the same way that real-world situations occur. Moreover, van Rooij (2009) emphasises on the importance of 'scaffolding' the situation so as to meet the different needs and capabilities of learners.

3.4 Problem-based Learning

Considering the flexibility of applying this learning model cross-disciplinary, employing the context of VEs as the learning space to enact or visualise case-based scenarios, promote social presence and enable learners to practice their skills stress-free, is considered to be highly beneficial to the students (Beaumont et al., 2014).

3.5 Game-based Learning

As Deterding et al. (2011) argue, gamified activities should be implemented with the same affordances required to design and develop virtual games. Nevertheless, as the psychological characteristics or affordances that stem from games are not explicitly identified, various instructional design approaches are framed under the 'gamification' idea (Hamari et al., 2014). A wide range of scientific fields have utilised this approach reporting that the playfulness of the activities made valuable contribution towards learners' experience and knowledge acquisition (Kim and Ke, 2017; Young et al., 2012).

3.6 Agent-based Learning

Pedagogical Agents (PAs) in VEs are employed to support the learning processes and provide additional instructional support (Terzidou and Tsiatsos, 2014; Grivokostopoulou et al., 2015). Nevertheless, the opinion that a portion of educators share regarding the usefulness of PAs to foster learner motivation and learning outcomes (Baylor and Kim, 2005) comes in opposition with the concerns that others raise, arguing that PAs may distract learners from the learning content and objectives (Dehn and van Mulken, 2000). Therein, instructional designers are advised to consider various factors concurrently and carefully—such as the learning environment and content, the target group which determines the learning goals and the interactivity spectrum of the agents—when designing PAs.

3.7 Summary

Similarly to the learning theories, each one of these models has unique characteristics that facilitate learning and enhance learners' experience. Nevertheless, researchers do not fail to mention the challenges, obstacles, and limitations that exist when integrating VEs for educational practices. Students' difficulty to adapt and familiarise with the interface or the implemented tools, the 3D modeling capabilities of this technology—which affect the realism and authenticity of the activities—or the elements that distract students' attention and thus, prevent them from focusing on their task, are only a few examples that educators should take into consideration prior to using virtual worlds.

In the following section, we present our perspective towards the structure and elements that instructional designers should consider offering their students when designing educational activities.

4 INSTRUCTIONAL DESIGN

The existence of our HVL curriculum offered a great opportunity to examine a set of instructional design decisions and also, their impact on interactions engagement. A university hosted virtual world, based on the OpenSimulator technology, was used to allow Computer Science students explore and familiarise themselves with the Linden Scripting Language—an Event Driven Programming Paradigm—and also, with the 3D modeling concepts. Figure 1 illustrates the narrative and logic which led to our decisions, while designing the in-world content, following the suggestions from researchers to combine multiple learning theories and models with the instructional design techniques and approaches (Pellas, 2014).

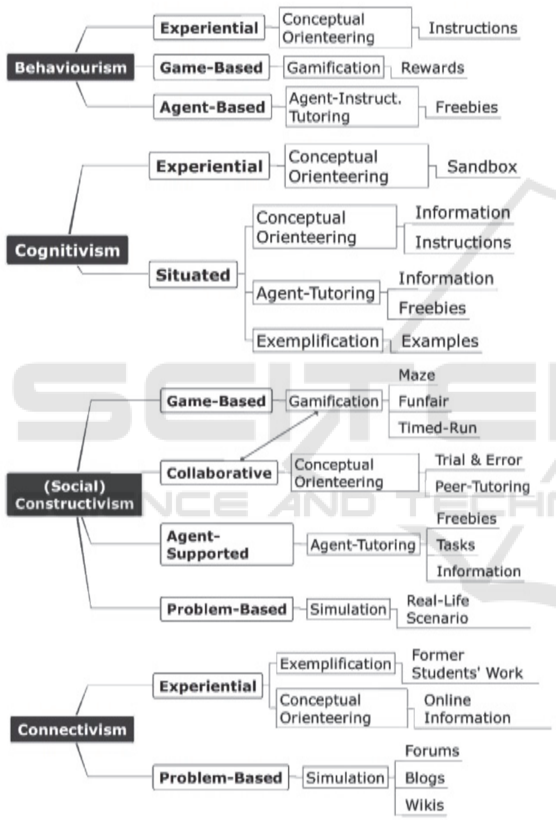

Figure 1: The correlations between the learning theories, models and our instructional design approach.

4.1 Methodology

Our research methodology, included a combination of both qualitative (observations) and quantitative (surveys) methods. Prior to elaborating further on that, an anecdotal observation, which became apparent from the very early stages of our first experiment, should be mentioned. Students' attitude and behaviour towards the VE as an educational tool was overwhelmed from negative attitude and emotions originating from their biases and preconceptions that 'VEs' are equivalent to 'Virtual Games'. Indeed, the academics in charge received manifold complaints suggesting that such medium has 'no place' in the university classroom and should be therefore discontinued from the teaching curriculum. As it was unclear how such behaviour could affect interactions and engagement, the distribution of a brief survey *a priori* to the conduct of the following experiments was considered critical. The aim of this survey was to enable us develop a clear idea of our sample's beliefs and preconceptions prior to using the VE so as to correlate them with the findings deriving from the *a posteriori* survey and the *observations.* As it concerns the observations, students' actions and interactions—both in the physical classroom and in the VE—were observed during their weekly practical sessions.

4.2 Exemplification

Exemplification is defined as "the ability to critically assess the use of examples in scientific communication" (Oliveira and Brown, 2016). The importance and effectiveness of exemplification to support conceptual understanding, provide supportive details about abstract concepts and engage learners with the phenomena they study has been highlighted by the aforementioned authors. Furthermore, as they consider exemplification as an emotion-related process, they argue that the high degree of vividness, when providing examples, is an integral part of this process. Moreover, Zillman and Brosius (2000) mention that by providing humans with examples enables them to associate the new features with past experiences and thus, help them develop lasting cognitive and emotional experiences.

In this scenario, the most well developed student work from a prior cohort was selected and utilised as examples for the newcomers. By providing such content, it was also expected that the incentives for interaction, not only between the students and the content of the world but also with each other, would increase (e.g. discussion, criticism). As far as the sample is concerned, *161* students participated in the *a posteriori* survey and *33* were observed during their laboratory work for *44 hours*.

4.3 Conceptual Orienteering

Educators who have used VEs stress the importance of providing students with enough time to familiarise themselves with the world and its tools (Jarmon et al., 2009; Savin-Baden et al., 2010).

However, the strict university time frames make that hard or even impossible. Considering that this is a time-consuming process, it is questionable whether or not instructional designers can facilitate, or even speed it up.

To facilitate this process, a 'school-like' building was developed, containing instructional information and practical exercises related to: the navigation tools, the avatars' editing appearance process, the use of the communication channels and the use and development of avatar gestures/animations. In addition, we offered students a sandbox area with information related to the 3D modeling process, as well as a park where they could socialise. In this experiment, *196* students participated in the *a priori* survey and *178* in the *a posteriori*. During the observations, *43* students agreed to participate and were observed for a total of *44 hours*.

4.4 Edutainment and Gamification

The employment of leisure games aimed at evoking strong childhood memories and further enhancing the already playful nature of the world. Interacting with the games would presumably increase the opportunities for interaction, not only with the content but also with other students.

For this scenario, the following content was available to students: an amusement park, a small lake, a café, a maze (question-based walls related to the theoretical material and in-world rewards), and a timed-run game. The sample of this experiment was *138* students who participated in the *a priori survey* and *133* in the *a posteriori*. Amongst them, *51* students were observed for *32 hours*.

4.5 Agent-based Instructional Tutoring

Baylor and Kim (2005) suggest that PAs can take various forms such as 'expert', 'motivator' or 'mentor'. In this scenario, *2 AI agents* with contradictory behaviours and characteristics and *1 non-AI NPC* were utilised to attract students' interest and attention in different manners. At this point, it should be noted that students were intentionally not informed about the presence and roles of the NPCs so as to allow them act naturally and discover their features as part of the exploration process.

The first NPC had a human-like form, resembling the role of the instructor or educator and was a conversational agent (programmed chatbot) with knowledge-intensive and domain-specific question answering capabilities. Its role was to facilitate the learning process and support students by providing useful and meaningful answers to technical-related queries. The second NPC was also a chatbot, though with nonhuman type ('monkey'), as an example of the contradictory content that VEs can accommodate. Its role was to disorientate students by providing incorrect or 'nonsense' answers to their queries in a 'ludicrous' way. The last NPC had a robot-like form, operating as vendor (task-specific/domain-specific information giver). Unlike the other NPCs who had also moving capabilities, this agent was immobilised, becoming interactive upon students' call. Its role was to provide students with informational notecards (digital text-based notes), assign tasks and offer 'freebies' (premade 3D objects and code). In total, *160* students filled in the *a priori* and *165* the *a posteriori* surveys. As to the observatory study, almost one third of them (*n=50*) was observed for a total of *30 hours*.

4.6 Summary

The prime objective of the aforementioned scenarios was to examine whether or not these processes could help learners acquire all the required knowledge and skills to cope with the learning activities. Moreover, for the validation of our data, we repeated each experiment three times, with different learning objectives and student cohorts. At this point, it should be noted that the context of each instructional approach was examined in isolation from the others so as to focus exclusively on one factor at a time.

5 DISCUSSION

One of the most important benefits of HVL is that instructional designers are in the position to examine the impact of their decisions, under the consideration of interaction and engagement, holistically and not just unilaterally. Through our study we had the opportunity to develop a better understanding towards our learners' needs and adjust our future plans based on their suggestions and recommendations. In this section, we discuss the core findings of each experiment.

Providing students with example content should be an integral part of the world's content. It enables learners to have a comparison measurement against their own aims and goals, turns the VE into a more authentic environment—which in turn contributes towards creating a wider community feeling—and may even be considered as a source pool of ideas.

Even though the new generations are considered as ‘digital natives’, offering learners with some form of guidance—especially at the starting point—can be truly helpful for those who are not familiar or comfortable with the idea of the 3D. Nonetheless, VEs also represent the idea of ‘freedom’ and ‘safety’ when it comes to trial and error. Considering this, along with the human nature to explore the unknown, it becomes apparent that it is fairly hard to patronise such procedures. Thereafter, chances are that students will rather attempt to explore the world and its tools by themselves, instead of going through *specific* or *framed* procedures. Nevertheless, having an information and instruction ‘fountain’ available at any given point might come handy.

Leisure games have potentially higher chances, as opposed to the educational ones, to attract learners’ interest and attention and therefore, engage them with the VE. Some of them may be inspired from this content, whereas others may perceive it purely as a way to break their routine and entertain themselves. In either case, the existence of game-like elements, in a relatively pure educational VE, can help students familiarise themselves with the in-world tools, or even make them perceive the learning process in a more enjoyable way. However, the impact of this content on the learning process is rather minimal or even non-existent.

Finally, regarding the usefulness and impact of the PAs on learner engagement, the results are very controversial. First, unlike the previous experiments where the instructional content was massive, the minimalistic appearance of the NPCs made them look and feel as part, or thereof not, of the system responsible for controlling and ensuring the proper operation of the VE. Nonetheless, the appearance of the NPCs—especially the nonhuman creature—attracted students’ attention as it was the ‘odd’ of the ecosystem. This agent received intense criticism for providing meaningless responses to ‘serious’ matters and therein, was interpreted as the ‘fun element’ of the world. The human-like agent was certainly more useful to address student queries, though only a small portion of them had intense interaction with this agent, probably due to the biases and preconceptions that have been developed from the behaviour of the aforementioned agent. Last but not least, the robot-like NPC was the one which truly added value to the learning process. Indeed, most of (if not all) the students would visit this agent fairly often to get advices, instructions or even ‘gifts’ (as it befalls in nearly all the workspaces).

6 CONCLUSIONS

Both types of interactions (in-world/in-class) play a crucial role in learner engagement, as they contribute to enhancing the benefits deriving from using the VE alone. Unlike virtual games, where the sense of in-world presence is a key factor, when it comes to HVL, immersion does not have much relevance or effect (if any). Furthermore, the in-world student-to-student interactions have a slightly lesser impact on learner engagement, compared to the ones that students have with the VE per se. Nevertheless, their impact on engagement and learning should not be disregarded.

The role of instructional designers is that of a ‘game changer’ in the teaching and learning process. Indeed, learners’ personal preferences, choices, or preconceptions, might come in opposition with the instructional design. However, it is of vital importance that learners receive clear information and instructions regarding the relevant content or even encourage them to use it, as it has been designed and developed in their favour.

Unarguably, not every learner will be attracted by the same learning approach. However, the higher the levels of interactivity are, the higher the chances to attract students’ attention and engagement with the process will be.

REFERENCES

Anderson, T., and Dron, J., 2011. Three generations of distance education pedagogy. *Int. Rev. of Research in Open and Dist. Learn.*, *12*(3), 80-97.

Baylor, A. L., and Kim, Y., 2005. Simulating instructional roles through pedagogical agents. *Artificial Int. in Edu.*, *15*(2), 95-115.

Beaumont, C., Savin-Baden, M., Conradi, E., and Poulton, T., 2014. Evaluating a Second Life Problem-Based Learning demonstrator project: What can we learn?. *Interactive Learning Environments*, *22*(1), 125-141.

Bossard, C., Kermarrec, G., Buche, C., and Tisseau, J., 2008. Transfer of learning in virtual environments: A new challenge?. *Virtual Reality (Waltham Cross)*, *12*(3), 151–161.

Bryceson, K., 2007. The online learning environment–A new model using social constructivism and the concept of ‘Ba’ as a theoretical framework. *Learning Environments Research*, *10*(3), 189-206.

Calleja, G., 2014. Immersion in virtual worlds. In M. Grimshaw (Ed.) *The Oxford Handbook of Virtuality*, 222–236. NY: Oxford University Press.

Camilleri, V., de Freitas, S., Montebello, M., and McDonagh-Smith, P., 2013. A case study inside virtual worlds: use of analytics for immersive spaces.

Proc. 3rd Int. Conf. on Learning Analytics and Knowledge, 230–234. Belgium: ACM.

Chen, C. J., 2009. Theoretical bases for using virtual reality in education. *Themes in Sci. Tech. Edu.*, *2*(1-2), 71-90.

Childs, M., 2010. A conceptual framework for mediated environments. *Educational Research*, *52(*2), 197–213.

Chodos, D., Stroulia, E., King S., Carbonaro, M., 2012. A framework for monitoring instructional environments in a virtual world. *BJoET*, *45*(1), 24-35.

Dalgarno, B., and Lee, M.J.W., 2010. What are the learning affordances of 3-D virtual environments?. *BJoET., 41*(1), 10–32.

Dehn, D.M., and van Mulken, S., 2000. The impact of animated interface agents: A review of empirical research. *J. Hum–Compt. Stud. 52*, 1–22.

Deterding, S., Dixon, D., Khaled, R., and Nacke, L., 2011. From game design elements to gamefulness: defining gamification. *Proc. 15th Int. Academic MindTrek Conf.: Envisioning Future Media Env.*, 9-15. Finland.

Dillenbourg, P., Schneider, D., Synteta, P., 2002. Virtual Learning Environments. *Proc. 3rd Hellenic Conf. Info. and Com. Tech. in Edu.*, 3-18. Rhodes:Greece.

Duncan, I. M. M., Miller, A. H. D., and Jiang, S. 2012. A taxonomy of virtual worlds usage in education. *BJoET*, *43*(6), 949-964.

Fardinpour, A., Reiners, T., 2014. The Taxonomy of Goal-oriented Actions in Virtual Training Environments. *Procedia Technology*, *13*, 38-46.

Fernández-Gallego, B., Lama, M., Vidal, J.C., Mucientes, M., 2013. Learning Analytics Framework for Educational Virtual Worlds. *Procedia Comp. Sci. 25*, 443-447.

Graham, C.R., 2013. Emerging practice and research in blended learning. In M. J. Moore (Ed.), *Handbook of distance education*, 333–350, 3rd ed. NY: Routledge.

Grivokostopoulou, F., Perikos, I., Konstantinos, K., and Hatzilygeroudis, I., 2015. Teaching Renewable Energy Sources Using 3D Virtual World Technology. *Proc. 15th IEEE Int. Conf. on Advanced Learn. Tech.*, 472-474. Hualien: Taiwan.

Grivokostopoulou, F., Perikos, I., Kovas, K., and Hatzilygeroudis, I., 2016. Learning Approaches in a 3D Virtual Environment for Learning Energy Generation from Renewable Sources. *Proc. 29th Int. FLAIRS Conference*, 497-500. Florida: USA.

Hamari, J., Koivisto, J., and Sarsa, H., 2014. Does Gamification Work? A Literature Review of Empirical Studies on gamification. *Proc. 47th Hawaii Int. Conf. on System Sciences*, 3025-3034. Hawaii: USA.

Hasler, B.S., 2011. Intercultural collaborative learning in virtual worlds. *Cutting-Edge Tech. High. Educ*., *4*, 265–304.

Jarmon, L., Traphagan, T., Mayrath, M., and Trivedi, A., 2009. Virtual world teaching, experiential learning, and assessment: An interdisciplinary communication course in Second Life. *Comp. and Edu.*, *53*(1), 169-182.

Jeong, H., and Chi, M.T.H., 2007. Knowledge convergence and collaborative learning. *Instructional Science*, *35*, 287-315.

Kim, H., and Ke, F., 2017. Effects of game-based learning in an OpenSim-supported virtual environment on mathematical performance. *Interactive Learning Environments, 25*(4), 543-557.

Klompmaker F., Paelke V., Fischer H., 2013. A Taxonomy-Based Approach towards NUI Interaction Design. In Streitz N., Stephanidis C. (Eds.) *Distributed, Ambient, and Pervasive Interactions*. *Lecture Notes in Computer Science*, *8028*. Springer.

Konstantinidis, A., Tsiatsos, Th., Pomportsis, A., 2009. Collaborative Virtual Learning Environments: Design and Evaluation. *Multimedia Tools and Applications, 44*(2), 279-304. Springer.

Kop, R., and Hill, A., 2008. Connectivism: Learning theory of the future or vestige of the past?. *Int. Review of Research in Open and Distance Learning, 9*(3).

Kronqvist, A., Jokinen, J., and Rousi, R., 2016. Evaluating the Authenticity of Virtual Environments: Comparison of Three Devices. *Advances in Human-Comp. Int.*, *2016*, 14 pages.

Lee, E.A.L., Wong, K.W., and Fung, C.C., 2010. How does desktop virtual reality enhance learning outcomes? A structural equation modelling approach. *Comp. and Edu.*, *55*(4), 1424-1442.

Loke, S.K., 2015. How do virtual world experiences bring about learning? A critical review of theories. *Australasian J. of Edu. Tech., 31*(1), 112-122. Ascilite.

Loureiro, A., Bettencourt, T., 2014. The use of virtual environments as an extended classroom - a case study with adult learners in tertiary education. *Procedia Technology*, *13*(2014), 97–106.

Nelson, B.C., and Erlandson, B.E., 2012. *Design for Learning in Virtual Worlds*. NY: Routledge.

Oliveira, A.W., and Brown, A.O., 2016. Exemplification in science instruction: Teaching and learning through examples. *Research in Sci. Teaching*, *53*(5), 737-767.

Omieno, K. K., Wanyembi, G., Mbugua, S., 2012. Integrating Virtual Worlds and Virtual Learning Environments in Schools in Developing Economies. *Int. J. of ICT Research*, *2*(1), 17-21.

Pellas, N., 2014. Bolstering the quality and integrity of online collaborative courses at university level with the conjunction of Sloodle and open simulator. *Edu. and Info. Tech*, *21*(5), 1007–1032.

Pellas, N., and Kazanidis, I., 2015. On the value of Second Life for students' engagement in blended and online courses: A comparative study from the Higher Education in Greece. *Edu. and Info. Tech.*, *20*(3), 445–466.

Pirker, J., 2013. *The Virtual TEAL World - An Interactive and Collaborative Virtual World Environment for Physics Education*. Master's thesis, Graz University of Technology.

Savin-Baden, M., Gourlay, L., Tombs, C., Steils, N., Tombs, G., and Mawer, M., 2010. Situating pedagogies, positions and practices in immersive virtual worlds. *Educational Research*, *52*(2), 123–133.

Siemens, G., 2005. Connectivism: A learning theory for the digital age. *Int. J. of Instruct. Tech. and Distance Learn., 2*(1), 3-10.

Terzidou, T., and Tsiatsos, Th., 2014. The impact of pedagogical agents in 3D collaborative serious games. *Proc. IEEE Global Eng. Edu. Conf*., 1–8. Istanbul: Turkey.

Twining, P., 2009. Exploring the Educational potential of Virtual Worlds – d Some Reflections From the SPP. *BJoET, 40*(3), 496-514.

van Rooij, W.S. (2009). Scaffolding project-based learning with the project management body of knowledge (PMBOK). *Comp. and Edu.*, *52*(1), 210-219.

Wang, F., and Burton, J. K., 2013. Second Life in education: A review of publications from its launch to 2011. *BJoET*, *44*(3), 357–371.

Young, W., Franklin, T., Cooper, T., Carroll, S., and Liu, C., 2012. Game-based learning aids in Second Life. *J. of Interactive Learning Research, 23*(1), 57–80.

Zillman, D., and Brosius, H.D., 2000. *Exemplification in communication: The influence of case reports on the perception of issues*. Mahwah, NJ: Lawrence Erlbaum Associates.